(19) JAPANESE PATENT OFFICE

PATENT ABSTRACTS OF JAPAN

(11) Publication number: 10188332 A

(43) Date of publication of application: 21 . 07 . 98

(51) Int. Cl G11B 7/135

(21) Application number: 09188703

(22) Date of filing: 14 . 07 . 97

(30) Priority: 23 . 07 . 96 JP 08193689
28 . 10 . 96 JP 08285544

(71) Applicant: ASAHI GLASS CO LTD

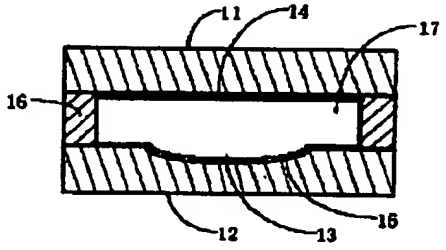
(72) Inventor: TANABE YUZURU
FUJINO YOUSUKE
KUROSAWA MITSURU

(54) OPTICAL HEAD DEVICE

(57) Abstract:

PROBLEM TO BE SOLVED: To obtain an optical head device whose miniaturization is easy and which has good productivity by allowing at least one side of liquid crystal cell substrates of liquid crystal to be arranged in between a beam splitter and optical recording mediums to have a projected part or a recessed part, allowing liquid crystal molecules being in the inside to be twisted and making a focus or the phase distribution of light beams variable by electrodes provided on the substrates to enhance the utilization efficiency of light beams.

SOLUTION: When a voltage is not impressed on electrodes 14, 15 of substrates 11, 12 being at upper and lower sides of a liquid crystal lens, light beams of P-polarized lights emitted from a light source pass through the beam spliter of a polarization system and light beams which are made circularity polarized lights of a clockwise direction by a phase difference plate 3 pass through liquid crystal lens by almost without being diffracted to be focused on a first optical recording medium. The light beam reflected from the first optical recording medium becomes a circularity polarized light to pass through the liquid crystal lens as it is and it is returned to a linearly polarixed light with the phase difference plate. When the voltage is impressed on the electrodes 14, 15, light beams of P-polarized lights emitted from the light source are made the polarized lights of a clockwise direction and they are focused on a second optical recording medium.



- 2 substrates
- phase
- electrodes (voltage)
- transparent substrates

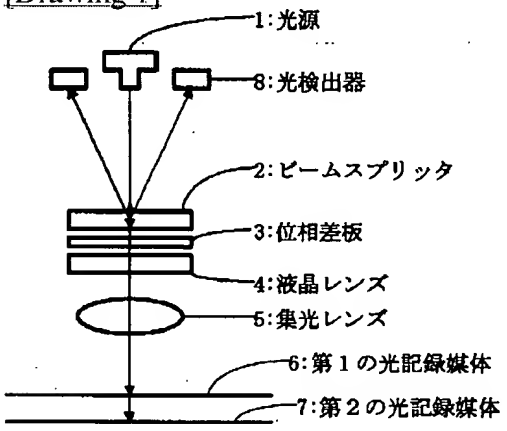
Best Art

* NOTICES *

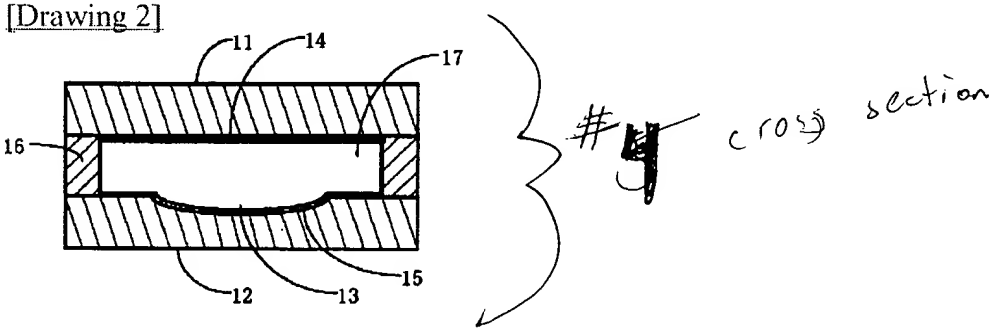
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

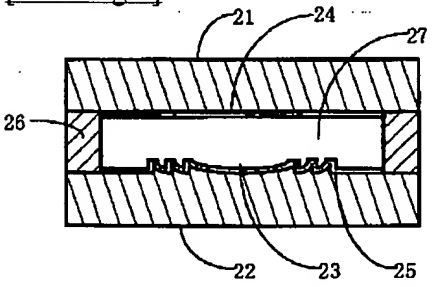
[Drawing 1]



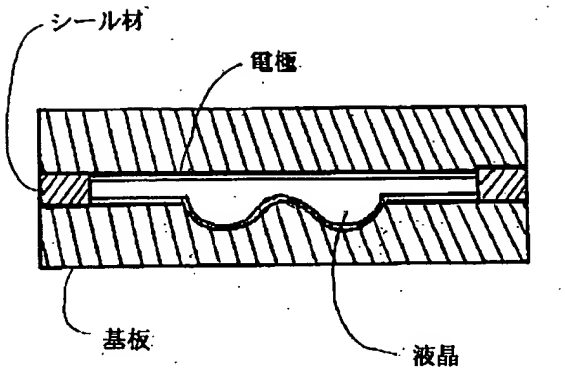
[Drawing 2]



[Drawing 3]



[Drawing 4]



[Translation done.]

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention writes optical information in optical record media, such as optical disks, such as CD (compact disk), CD-ROM, and a videodisk, and a magneto-optic disk, or relates to the optical head equipment for reading optical information.
[0002]
[Description of the Prior Art] The following configurations were taken, in order to write optical information in optical recording media, such as an optical disk and a magneto-optic disk, conventionally or for one optical head equipment to realize R/W of a signal in the optical head equipment which reads optical information to the disk of different thickness like CD/CD-ROM, and a DVD disk.
[0003] For example, making light with two foci with one optical head equipment has been performed by forming a Fresnel lens type blaze hologram on the surface of a lens, diffracting abbreviation one half in the direction in which a beam spreads by the hologram among the light which carried out incidence to the lens from semiconductor laser, making the remaining one half penetrate as it is, and making each beam converge with the body of a lens after that. Moreover, a lens is made into the same thing as usual, and dissociating separately and also making a Fresnel hologram lens plate with the same function as the above arrange is tried.
[0004] However, by these methods, the quantity of light of light became half on the outward trip by the above-mentioned hologram, and since the quantity of light became half again also in the return trip, there was a problem from which the quantity of light becomes 1/4 or less both ways.
[0005] For this reason, in the case of the optical head equipment with which obtaining a big output especially used the semiconductor laser of difficult red, the load to the light source became large and there was a problem which brings about the increment in power consumption, enlargement of optical head equipment, the rise of cost, and the fall of dependability.
[0006] Moreover, the lens with which the focal distances of two pieces differ was prepared, and although using it, changing it mechanically was also performed, since it was used having made it move mechanically, there was a problem which brings about enlargement of optical head equipment, the rise of cost, and the fall of dependability.
[0007]
[Problem(s) to be Solved by the Invention] This invention solves the above-mentioned problem and raises the use effectiveness of light, and a miniaturization is easy and it aims at offer of the optical head equipment incorporating 2 focal lens which can be manufactured with cheaply sufficient productivity. Moreover, it aims at offer of the optical head equipment incorporating 2 focal lens which can also use the so-called polarization system using a polarization hologram or a polarization beam splitter.
[0008]
[Means for Solving the Problem] In the optical head equipment with which this invention has the light source, a beam splitter, a liquid crystal lens, and a photodetector As a liquid crystal lens arranged between a beam splitter and an optical recording medium At least one side of the substrate of a liquid crystal cell has a crevice or heights, the liquid crystal with which the interior was filled up is twisting, and the optical head equipment characterized by using what made adjustable phase distribution of a focal distance or light with the electrode prepared in some substrates [at least] is offered.
[0009] Moreover, it sets to the optical head equipment which has the light source, a beam splitter, a liquid

crystal lens, and a photodetector. As a liquid crystal lens arranged between a beam splitter and an optical recording medium Have the crevice or heights at least with detailed one side of a substrate of a liquid crystal cell, and it considers as Fresnel lens structure. The liquid crystal with which the interior was filled up is twisting and the optical head equipment characterized by using what made adjustable phase distribution of a focal distance or light with the electrode prepared in some substrates [at least] is offered.

[0010] Furthermore, when wavelength in P and a vacuum is set [the optical head equipment made almost monotonous / the substrate of the central part of those liquid crystal lenses /, and the Tsunemitsu refractive index of those liquid crystal / no and an extraordinary index] to lambda for ne and a twist pitch, the optical head equipment which is 2 (ne-no) P/(8lambda) <=0.05 is offered.

[0011] Furthermore, the optical head equipment using the polarization diffraction component filled up with the optical anisotropy ingredient between substrates is offered as the optical head equipments which made the refractive index of those substrates almost equal to the average of the Tsunemitsu refractive index of liquid crystal, an extraordinary index or the Tsunemitsu refractive index, and an extraordinary index, and those beam splitters, using the substrate which prepared the grid-like crevice as one [at least] substrate.

[0012] In this invention, since the liquid crystal lens is used, in phase distribution of a focal distance or light, it is switchable and optical head equipment with high use effectiveness is obtained by the electrical-potential-difference impression from the outside.

[0013]

[Embodiment of the Invention] Drawing 1 is the mimetic diagram showing the fundamental configuration of this invention. drawing 1 -- setting -- 1 -- the light sources, such as semiconductor laser, and 2 -- a beam splitter and 3 -- in a phase contrast plate and 4, the 1st optical recording medium and 7 show the 2nd optical recording medium, and, as for a liquid crystal lens and 5, 8 shows a photodetector, as for a condenser lens and 6.

[0014] A beam splitter 2 is passed, the phase contrast plate 3 is passed, the liquid crystal lens 4 is passed, it is condensed with a condenser lens 5, and the light which came out of the light source 1 reaches an optical recording medium. a ****** [impressing an electrical potential difference to a liquid crystal lens here] -- or by changing the electrical potential difference to impress, the focal distance of a liquid crystal lens or phase distribution of light is changed, and a focus is doubled with the 1st optical recording medium 6 or 2nd optical recording medium 7. In addition, a beam splitter can use polarization beam splitters, such as a prism-like thing and a liquid crystal hologram, by this invention.

[0015] The light which reflected and has returned from this optical recording medium carries out sequential passage of a condenser lens 5, the liquid crystal lens 4, the phase contrast plate 3, and the beam splitter 2 again, and the light separated by the beam splitter 2 reaches a photodetector 8.

[0016] Drawing 2 is the sectional view showing the example of the liquid crystal lens with which a substrate has a crevice or heights. In drawing 2 , the crevice where 11 and 12 were prepared in the substrate and 13 was prepared in the substrate, and 14 and 15 show the liquid crystal with which the surrounding sealant was filled up with an electrode and 16 and it filled up with 17 between substrates.

[0017] Transparence substrates, such as plastics and glass, can be used for these substrates 11 and 12. A crevice or heights is formed in one [at least] inside side (liquid crystal side) of this substrate. The crevice is formed in a substrate 12 side in this drawing. These crevice or heights may be formed in the substrate itself, and may form an organic or inorganic transparent membrane in a front face at a predetermined configuration.

[0018] What is necessary is to delete this processing mechanically, to carry out press forming, or to etch it, and just to form it, when forming in the substrate itself. When forming an organic or inorganic transparent membrane in a front face, after forming in the whole surface, a transparent membrane may be deleted like the case of the substrate itself, or may be etched, and may be formed, and you may make deposit, or print and form in a direct predetermined pattern.

[0019] Drawing 3 is the sectional view showing the example of the liquid crystal lens which made the substrate Fresnel lens structure. In drawing 3 , the concave heights of the Fresnel lens structure where 21 and 22 were prepared in the substrate and 23 was prepared in the substrate, and 24 and 25 show the liquid crystal with which the surrounding sealant was filled up with an electrode and 26 and it filled up with 27 between substrates. It can form by the approach of forming a crevice or heights in the substrate which also described above the concave heights of this Fresnel lens structure, and the same approach.

[0020] It is almost satisfactory, even if the irregularity of these lenses is completely good also as a predetermined configuration, and it makes only a core into a flat configuration and uses so that processing may become easy. When considering as Fresnel lens structure especially, processing becomes easy and is desirable by making the core flat. This core means the field inside about 20 - 60% of path to the outer diameter of a lens.
[0021] Transparent electrodes, such as the usual ITO, can be used for electrodes 14, 15, 24, and 25. Usually, although to consider as a whole surface solid electrode is possible, patterning is carried out, for example to the shape of a ring, and a lens operation can be made to be changed partially. Moreover, a metal wire etc. can also be prepared and formed into low resistance to a part.
[0022] Moreover, although not illustrated, orientation film, such as polyimide, a polyamide, and SiO, is formed and used on this electrode. In a typical example, the polyimide film is formed, rubbing of the front face is carried out and the orientation film is formed. Liquid crystal cannot twist the direction of rubbing of this orientation film between two substrates, or can use it.
[0023] Thus, two formed substrates are arranged so that an electrode side may counter, and it pastes up by sealants 16 and 26 on the outskirts, and the interior is filled up with liquid crystal 17 and 27. The usual nematic liquid crystal is used as this liquid crystal.
[0024] Subsequently, actuation of optical head equipment is explained. The light which came out of the light source 1 presupposes that it has the linearly polarized light (polarization of a direction parallel to space), for example, P polarization. The nematic liquid crystal of a dielectric anisotropy forward with the liquid crystal lens of drawing 2 is used, and it is the Tsunemitsu refractive index no of liquid crystal about the refractive index of a substrate 12. Extraordinary index ne The direction of rubbing by the side of the light source of the orientation film is carried out in the direction parallel to space using the thing it was made in agreement [thing] with middle value (no+ne)/2.
[0025] In this case, supposing liquid crystal is twisting in the twist pitch P (pitch twisted 360 degrees) by right hand, the effectual refractive index of the liquid crystal to the light of the right-handed-rotation circular polarization of light is expressed as /2+(ne-no)2 P/(8lambda) in approximation (ne+no). Moreover, the effectual refractive index of the liquid crystal to the light of the left-handed-rotation circular polarization of light is expressed as /2-(no-ne)2 P/(8lambda) in approximation (no+ne).
[0026] When the liquid crystal lens 4 is an OFF state, in the substrate by the side of the light source, orientation of the liquid crystal is carried out in the direction [almost parallel to a substrate and] parallel to space. Suppose that orientation is carried out at an include angle which is different from whenever [orientation angle / of the substrate by the side of the light sources, such as a distorted condition,] 90 degrees, for example in the substrate of the opposite side (optical-recording-medium side).
[0027] On an outward trip, the light which came out of the light source 1 passes a beam splitter 2, subsequently to the right-handed-rotation circular polarization of light, is carried out with the phase contrast plates 3, such as lambda/4 plate, and carries out incidence to the liquid crystal lens 4. This beam splitter 2 is made the polarization system beam splitter which functions as a beam splitter or does not function by the polarization direction of light.
[0028] Comparing with (ne+no) / 2 at this time, supposing 2 (ne-no) P/(8lambda) is small, the effectual refractive index of liquid crystal will become almost equal to /2 in approximation (ne+no) to the light of the right-handed-rotation circular polarization of light. For this reason, on an outward trip, the light of the refractive index [the refractive index (middle of the Tsunemitsu refractive index of liquid crystal and an extraordinary index) of a substrate and] of distorted liquid crystal which came out of the light source 1 will correspond mostly, and since the refractive index is equal, light goes straight on mostly, without being refracted. And it is condensed with a condenser lens 5 and a focus is connected to the 1st optical recording medium 6.
[0029] In a return trip, it becomes the counterclockwise circular polarization of light, a condenser lens 5 and the liquid crystal lens 4 which is not functioning as lenses are passed again, it is returned to the linearly polarized light with the phase contrast plate 3, light is separated by the beam splitter 2, and the light reflected on the front face of the 1st optical recording medium 6 reaches a photodetector 8.
[0030] Moreover, in this invention, it becomes important that the effective refractive index of the liquid crystal section to the right-handed-rotation circular polarization of light and the effective refractive index of the liquid crystal section to the left-handed-rotation circular polarization of light are almost equal within limits permitted

practically. For that purpose, as for a pitch P, it is desirable that it is not so large. As for a pitch P, it is desirable to be made 5 micrometers or less, and, specifically, it is desirable to make it especially 3 micrometers or less.
[0031] moreover, the ratio of the pitch P of liquid crystal, and thickness d of a liquid crystal layer -- when d/P exceeds 1.0, it is in the inclination for the turn-off time to increase substantially, for light scattering by the focal conic condition that the liquid crystal screw axis was confused at the time of electrical-potential-difference OFF. For this reason, it is desirable to enlarge, the include angle, i.e., the pre tilt angle, of a liquid crystal orientation vector and a substrate side near [which makes viscosity of liquid crystal low] a substrate interface to make, etc.
[0032] If an electrical potential difference is impressed to the liquid crystal lens 4 and it is turned on, liquid crystal will align in the direction of electric field, and will carry out orientation to a substrate in (the vertical direction of space) mostly at a perpendicular. For this reason, on an outward trip, the light which came out of the light source 1 passes a beam splitter 2, subsequently to the right-handed-rotation circular polarization of light, is carried out with the phase contrast plate 3, and carries out incidence to the liquid crystal lens 4.
[0033] The refractive index (middle of the Tsunemitsu refractive index of liquid crystal and an extraordinary index) of a substrate and the refractive index (it becomes the Tsunemitsu refractive index) of liquid crystal will not be in agreement, it will function as a concave lens, and light is refracted here. For this reason, when condensed with a condenser lens 5, a focal distance becomes long, and a focus is connected to the 2nd optical recording medium 7.
[0034] In a return trip, it becomes the left-handed-rotation circular polarization of light, a condenser lens 5 and the liquid crystal lens 4 which is functioning as concave lenses are passed again, it is returned to the linearly polarized light with the phase contrast plate 3, light is separated by the beam splitter 2, and the light reflected on the front face of the 2nd optical recording medium 7 reaches a photodetector 8.
[0035] Although the substrate 12 used the substrate which has a crevice in the above-mentioned example, if the substrate which has heights with the same configuration is used, it will function as a convex lens. Moreover, it is the Tsunemitsu refractive index no of liquid crystal about the refractive index of a substrate 12. If the thing it was made in agreement [thing] is used, when a substrate 12 uses the substrate which has a crevice at the time of electrical-potential-difference OFF, it functions as a convex lens, and when the substrate which has heights is used, it will function as a concave lens.
[0036] In this case, orientation processing of the substrate of both sides with which the substrate of both sides carries out level orientation processing only of the substrate of one side which carries out level orientation processing, and which carries out level orientation processing only of the substrate of one side, and carries out perpendicular orientation processing of the substrate of another side carrying out perpendicular orientation processing is possible for orientation processing.
[0037] What is necessary is just to perform perpendicular orientation processing by the approach of processing an electrode substrate front face with an organic silane, lecithin, a surfactant, etc. Moreover, what is necessary is just to perform level orientation processing with organic [which was formed an electrode, a substrate, or on it], the approach of rubbing inorganic overcoat material to an one direction with cloth etc., the method vacuum deposition of slanting, etc.
[0038] In addition, the light source used for usual optical head equipment can be used for the light source 1 used by this invention. Although the light source by semiconductor laser is the most common, specifically, the light source which combined other laser and wavelength sensing elements can also be used.
[0039] Only the light of the specific polarization direction is made to diffract, the light from the light source of an outward trip passes as it is, and a beam splitter 2 carries out diffracting or reflecting etc., makes light a photodetector reach, and should just deal in the light of a return trip. Specifically, a diffraction grating, the diffraction grating using liquid crystal, compound prism, etc. can be used. The diffraction grating using the liquid crystal which makes only the light of the specific polarization direction diffract especially is suitable. A phase contrast plate with lambda/4 well-known plate which changes into the circular polarization of light the light which carried out incidence by the linearly polarized light can be used for the phase contrast plate 3.
[0040] A condenser lens 5 is a lens for making either the 1st optical recording medium or the 2nd optical recording medium condense light. When all function as a lens to some extent, in the state of either of the busy condition, the liquid crystal lens 4 makes either the 1st optical recording medium or the 2nd optical recording

medium condense, and sells light at an electrical-potential-difference ON state and an OFF state to it.
[0041]
[Example]
As shown in "Example 1" drawing 2 , as for the core of a glass substrate at the bottom, the refractive index formed [magnitude] the crevice 13 in the shape of an aspheric surface concave lens with a press by 10x10mm at 0.5mm in thickness, using the glass substrate of 1.57 as substrates 11 and 12. This aspheric lens set the diameter of 2mm, and the main depth to 5 micrometers. As electrodes 14 and 15, after forming an ITO electrode, the substrates 11 and 12 of a top face and an inferior surface of tongue applied and carried out rubbing of the film of polyimide, and performed level orientation processing.
[0042] These two substrates 11 and 12 were made to counter so that each direction of orientation may become parallel, the seal was carried out on the outskirts, and the gap formed the empty cel whose gap is 5 micrometers by 10 micrometers and the periphery in the lens core. In addition, the antireflection film was formed in the external surface of substrates 11 and 12, respectively.
[0043] As liquid crystal 17, in this empty cel, 0.1 and the twist pitch P poured in the nematic liquid crystal constituent of the forward dielectric anisotropy which is 10 micrometers, 1.52 and deltan closed the inlet, and the Tsunemitsu refractive index manufactured the liquid crystal lens in it.
[0044] As shown in drawing 1 , when this liquid crystal lens 4 is arranged and the permeability of the circular polarization of light of right-handed rotation with a wavelength of 650nm and left-handed rotation was measured, by the clockwise circular polarization of light (outward trip in optical head equipment), 95%, also by the counterclockwise circular polarization of light (return trip in optical head equipment), it is 95% of effectiveness and 90% of effectiveness was acquired both ways.
[0045] First, the case where an electrical potential difference is not impressed between the electrode 14 of the substrates 11 and 12 of the upper and lower sides of the liquid crystal lens 4 and 15 is explained. The light of P polarization (the polarization direction parallel to space) which came out of the light source 1 passed the beam splitter 2 of a polarization system, with the liquid crystal lens 4, the light which turned into the clockwise circular polarization of light with the phase contrast plate 3 was hardly refracted, and passed, and its focus suited to the 1st optical recording medium 6.
[0046] The light reflected with this 1st optical recording medium 6 turns into the counterclockwise circular polarization of light, it passes the liquid crystal lens 4 almost as it is again, is returned to the linearly polarized light with the phase contrast plate 3, turns into light of S polarization (the polarization direction perpendicular to space), and carries out incidence to the beam splitter 2 of a polarization system. The light of S polarization was diffracted by the beam splitter 2, and reached the photodetector 8.
[0047] On the other hand, the case where the electrical potential difference of 100Hz and 5V is impressed between the electrode 14 of the substrates 11 and 12 of the upper and lower sides of the liquid crystal lens 4 and 15 is explained. The light of P polarization (the polarization direction parallel to space) which came out of the light source 1 passed the beam splitter 2 of a polarization system, the light which turned into the clockwise circular polarization of light with the phase contrast plate 3 was refracted with the liquid crystal lens 4, and its focus suited to the 2nd optical recording medium 7.
[0048] The light reflected with this 2nd optical recording medium 7 turns into the counterclockwise circular polarization of light, it is again refracted with the liquid crystal lens 4, is returned to the linearly polarized light with the phase contrast plate 3, turns into light of S polarization (the polarization direction perpendicular to space), and carries out incidence to the beam splitter 2 of a polarization system. The light of S polarization was diffracted by the beam splitter 2, and reached the photodetector 8.
[0049] The same glass substrate was used instead of the liquid crystal lens of the example 1 of "Example 2", and as shown in drawing 3 , the concave heights 23 of Fresnel lens structure were boiled with a press, and were formed more. The concave heights 23 of Fresnel lens structure set the diameter of 2mm, and the main depth to 2 micrometers. The gap in a periphery set to 4 micrometers, and also the empty cel was formed like Example 1.
[0050] As liquid crystal 27, in this empty cel, 0.1 and the twist pitch P poured in the nematic liquid crystal constituent of the forward dielectric anisotropy which is 4 micrometers, 1.52 and deltan closed the inlet, and the Tsunemitsu refractive index manufactured the liquid crystal lens in it.
[0051] This liquid crystal lens was built into the optical head equipment of a configuration like drawing 1 like

Example 1. When the permeability of the circular polarization of light of right-handed rotation with a wavelength of 650nm and left-handed rotation was measured, by the clockwise circular polarization of light (outward trip in optical head equipment), 95%, also by the counterclockwise circular polarization of light (return trip in optical head equipment), it is 95% of effectiveness and 90% of effectiveness was acquired both ways. The focus was able to be changed by ON of the electrical potential difference of 100Hz and 5V, and OFF like Example 1.

[0052] As shown in "Example 3" drawing 2 , as for the core of a glass substrate at the bottom, the refractive index formed [magnitude] the crevice 13 in the shape of an aspheric surface concave lens with a press by 10x10mm at 0.5mm in thickness, using the glass substrate of 1.62 as substrates 11 and 12. This aspheric lens set the diameter of 2mm, and the main depth to 5 micrometers. The substrates 11 and 12 of a top face and an inferior surface of tongue formed the ITO electrode as electrodes 14 and 15. Subsequently, rubbing of the film of polyimide was applied and carried out to the substrate 11 on top, and level orientation processing was performed. Moreover, the perpendicular orientation agent of an organic silane system was applied to the substrate 12 at the bottom.

[0053] These two substrates 11 and 12 were made to counter so that each direction of orientation may become parallel, the seal was carried out on the outskirts, and the gap formed the empty cel whose gap is 5 micrometers by 10 micrometers and the periphery in the lens core. In addition, the antireflection film was formed in the external surface of substrates 11 and 12, respectively.

[0054] As liquid crystal 17, in this empty cel, 0.2 and the twist pitch P poured in the nematic liquid crystal constituent of the forward dielectric anisotropy which is 2 micrometers, 1.52 and deltan closed the inlet, and the Tsunemitsu refractive index manufactured the liquid crystal lens in it.

[0055] This liquid crystal lens was built into the optical head equipment of a configuration like drawing 1 like Example 1. When the permeability of the circular polarization of light of right-handed rotation with a wavelength of 650nm and left-handed rotation was measured, by the clockwise circular polarization of light (outward trip in optical head equipment), 95%, also by the counterclockwise circular polarization of light (return trip in optical head equipment), it is 95% of effectiveness and 90% of effectiveness was acquired both ways. The focus was able to be changed by ON of the electrical potential difference of 100Hz and 5V, and OFF like Example 1.

[0056] "Example 4" The refractive index used [magnitude] the glass substrate of 1.57 by 10x10mm by 0.5mm in thickness as two substrates. The glass substrate at the bottom formed heights in the shape of an aspheric surface convex lens by etching so that a core might become heights. This aspheric lens set the diameter of 1.5mm, and main height to 4 micrometers. As an electrode, after forming an ITO electrode, the substrate of a top face and an inferior surface of tongue applied and carried out rubbing of the film of polyimide, and performed level orientation processing.

[0057] These two substrates were made to counter so that each direction of orientation may become parallel, the seal was carried out on the outskirts, and the gap formed the empty cel whose gap is 8 micrometers by 4 micrometers and the periphery in the lens core. In addition, the antireflection film was formed in the external surface of two substrates, respectively.

[0058] As liquid crystal, in this empty cel, 0.12 and the twist pitch P poured in the nematic liquid crystal constituent of the forward dielectric anisotropy which is 3 micrometers, 1.49 and deltan closed the inlet, and the Tsunemitsu refractive index manufactured the liquid crystal lens in it.

[0059] Thus, in the condition that the manufactured liquid crystal lens does not impress an electrical potential difference, the molecule of liquid crystal has the helical structure and the screw axis becomes perpendicular to a substrate side. For this reason, the effective refractive index of liquid crystal becomes the middle value 1.55 of the Tsunemitsu refractive index 1.49 and an extraordinary index 1.61 to light with a wavelength of 633nm which carried out incidence at right angles to a substrate side. From this, the refractive-index difference of the refractive index of liquid crystal and the refractive index of a substrate became small, and phase distribution of the light which penetrated the liquid crystal lens hardly changed to the condition before transparency.

[0060] Next, if the electrical potential difference of 100Hz and 10V is impressed to inter-electrode [of the substrate of the upper and lower sides of a liquid crystal lens], a liquid crystal molecule will be in a vertical orientation condition. For this reason, to light with a wavelength of 633nm which carried out incidence at right

angles to a substrate side, the effective refractive index of liquid crystal becomes equal to the Tsunemitsu refractive index 1.49. The refractive-index difference of the refractive index of liquid crystal and the refractive index of a substrate became large, and phase distribution of the light which penetrated the liquid crystal lens changed from this so that it might be proportional to the aspheric surface configuration height formed in the substrate side of a cel.

[0061] When it used with the configuration of drawing 1 and an electrical potential difference was not impressed to inter-electrode [of the substrate of the upper and lower sides of the liquid crystal lens 4] by this, the signal from the 1st optical recording medium 6 could be read, and when an electrical potential difference was impressed, the signal from the 2nd optical recording medium 7 was able to be read.

[0062] The same glass substrate as the example 4 of "Example 5" was used. However, the glass substrate at the bottom formed heights in the shape of an aspheric surface convex lens by etching so that a core might become heights. This aspheric lens set the diameter of 1.5mm, and main height to 3 micrometers. As an electrode, after forming an ITO electrode, the solvent of an organic silane system was applied to the glass substrate of this inferior surface of tongue, and perpendicular orientation processing was performed to it. On the other hand, after the glass substrate on top formed the ITO electrode as an electrode, it applied and carried out rubbing of the film of polyimide, and performed level orientation processing.

[0063] These two substrates were made to counter, the seal was carried out on the outskirts, and the gap formed the empty cel whose gap is 6 micrometers by 3 micrometers and the periphery in the lens core. In addition, the antireflection film was formed in the external surface of two substrates, respectively.

[0064] As liquid crystal, in this empty cel, 0.12 and the twist pitch P poured in the nematic liquid crystal constituent of the forward dielectric anisotropy which is 1.6 micrometers, 1.49 and deltan closed the inlet, and the Tsunemitsu refractive index manufactured the liquid crystal lens in it.

[0065] Thus, in the condition that the manufactured liquid crystal lens does not impress an electrical potential difference, the molecule of liquid crystal has the helical structure and the screw axis becomes perpendicular to a substrate side. For this reason, the effective refractive index of liquid crystal becomes the middle value 1.55 of the Tsunemitsu refractive index 1.49 and an extraordinary index 1.61 to light with a wavelength of 633nm which carried out incidence at right angles to a substrate side. From this, the refractive-index difference of the refractive index of liquid crystal and the refractive index of a substrate became small, and phase distribution of the light which penetrated the liquid crystal lens hardly changed to the condition before transparency.

[0066] Next, if the electrical potential difference of 100Hz and 10V is impressed to inter-electrode [of the substrate of the upper and lower sides of a liquid crystal lens], a liquid crystal molecule will be in a vertical orientation condition. For this reason, to light with a wavelength of 633nm which carried out incidence at right angles to a substrate side, the effective refractive index of liquid crystal becomes equal to the Tsunemitsu refractive index 1.49. The refractive-index difference of the refractive index of liquid crystal and the refractive index of a substrate became large, and phase distribution of the light which penetrated the liquid crystal lens changed from this so that it might be proportional to the aspheric surface configuration height formed in the substrate side of a cel.

[0067] When it used with the configuration of drawing 1 and an electrical potential difference was not impressed to inter-electrode [of the substrate of the upper and lower sides of the liquid crystal lens 4] by this, the signal from the 1st optical recording medium 6 could be read, and when an electrical potential difference was impressed, the signal from the 2nd optical recording medium 7 was able to be read.

[0068] As shown in "Example 6" drawing 4 , magnitude formed the crevice in the shape of an aspheric surface concentric circle with a press by 0.5mm in thickness so that a refractive index might become a glass substrate at the bottom with the crest of the height as the flat part of a substrate with the same core by 10x10mm, using the glass substrate of 1.49 as two substrates. This aspheric lens set the diameter of 2.3mm, and the depth of a crevice to 2.3 micrometers. As an electrode, after forming an ITO electrode, the substrate of a top face and an inferior surface of tongue applied and carried out rubbing of the film of polyimide, and performed level orientation processing.

[0069] These two substrates were made to counter so that each direction of orientation may become parallel, the seal was carried out on the outskirts, and the gap formed the empty cel whose gap is 6.3 micrometers in 4 micrometers and a crevice in the lens core. In addition, the antireflection film was formed in the external surface

of two substrates, respectively.
[0070] As liquid crystal, in this empty cel, 0.12 and the twist pitch P poured in the nematic liquid crystal constituent of the forward dielectric anisotropy which is 1.6 micrometers, 1.49 and deltan closed the inlet, and the Tsunemitsu refractive index manufactured the liquid crystal lens in it.
[0071] Thus, in the condition that the manufactured liquid crystal lens does not impress an electrical potential difference, the molecule of liquid crystal has the helical structure and the screw axis becomes perpendicular to a substrate side. For this reason, the effective refractive index of liquid crystal becomes the middle value 1.55 of the Tsunemitsu refractive index 1.49 and an extraordinary index 1.61 to light with a wavelength of 633nm which carried out incidence at right angles to a substrate side. The refractive-index difference of the refractive index of liquid crystal and the refractive index of a substrate became large, and phase distribution of the light which penetrated the liquid crystal lens changed from this so that it might be proportional to the aspheric surface configuration height formed in the substrate side of a cel.
[0072] Next, if the electrical potential difference of 100Hz and 10V is impressed to inter-electrode [of the substrate of the upper and lower sides of a liquid crystal lens], a liquid crystal molecule will be in a vertical orientation condition. For this reason, to light with a wavelength of 633nm which carried out incidence at right angles to a substrate side, the effective refractive index of liquid crystal becomes equal to the Tsunemitsu refractive index 1.49. From this, the refractive-index difference of the refractive index of liquid crystal and the refractive index of a substrate became small, and phase distribution of the light which penetrated the liquid crystal lens hardly changed to the condition before transparency.
[0073] When it used with the configuration of drawing 1 and an electrical potential difference was not impressed to inter-electrode [of the substrate of the upper and lower sides of the liquid crystal lens 4] by this, the signal from the 2nd optical recording medium 7 could be read, and when an electrical potential difference was impressed, the signal from the 1st optical recording medium 6 was able to be read.
[0074]
[Effect of the Invention] With the optical head equipment of this invention, since the liquid crystal lens which liquid crystal twisted is used, by electrical-potential-difference impression from the outside, it is switchable in phase distribution of a focal distance or light, and optical head equipment with high use effectiveness can be obtained. This invention can perform various application within limits which do not lose the effectiveness.

[Translation done.]